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Wireless Sensors Network Based Safe Home to Care Elderly People: Behaviour Detection

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Abstract

The age span of elder people is increasing and this trend may continue in near future. Elder people wish to stay as independently as possible and are keen on fulfilling lives, but self-regulating ways of life involve with risks, such as weakening, memory loss or impaired judgment and falling that limit mobility. In particular, the daily home activity involving basic functions like preparing breakfast or food, showering, walking, sleeping, watching television, reading books etc., is a key indicator in determining the performance of elder home activity. A intelligent, robust, less cost, flexible and real time home monitoring system has been developed to record the basic home activities and respond immediately when there is a change in the regular daily activity of the elder person. This paper will report our recent works based on trial work of the system to determine the behaviour of elderly person activity.

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Keywords: Smart home; wireless sensors network; intelligent algorithm; behavior detection; abnormality; emergency button.

1. Introduction

People are living longer than before. But with old age, the probability of accidents and consequently hospitalization has increased considerably. A lot of researches on the development of monitoring system of the activities of the elderly person living at home have been reported [1-6]. In the present work, an intelligent home monitoring unit based on ZigBee wireless sensors has been designed and developed to assist and monitor the activities of the elderly people [7-10]. The system works on the principle of using sensor units (SU) to monitor the basic appliances used for the day-to-day life of the elderly person being monitored. The system does not use any camera and or vision sensors as it intrudes privacy and is not acceptable by many elderly people. Several levels of alarm conditions have been incorporated based on the inference rules generated from the knowledge base. Apart from inference rule checks, the knowledge base can be customized in relation to the need of the activity of a particular individual. The topology of the ZigBee sensor network is mesh connected and a central coordinator of the sensors collect the data from the sensors connected to various appliances. The developed intelligent program continuously reads the data from the coordinator and efficiently stores on the system for further data processing in real time. The data processing involves steps for multi-level check on the knowledge base for predicting the change in the normal activity pattern of the system. In this system, an optimum numbers of sensors for

monitoring the basic activity of the elder behaviour are used as this is sufficient for monitoring essential activities of elder behaviour. Increase of number of sensors increases the cost of the system and may also increase the installation issues.

2. System Description

The developed system consists of two basic modules. At the low level module, Wireless sensor network of mesh structure exists capturing the sensor data based on the usage of house hold appliances and stores the data in the computer system for further data processing. Collected sensor data is of low level information containing only status of the sensor as active or inactive and identity of the sensor. To sense the activity behaviour of elder in real time, the next level software module will analyze the collected data by following an intelligent mechanism at various level of data abstraction based on time and sequence behaviour of sensor usage.

The low level module consists of required number of smart sensors interconnected to detect usage of electrical devices, bed usage and other non electrical devices with emergency button. Fabricated smart sensors communicate through Zigbee protocols and provide sensor information that can be used to monitor the daily activities of the elderly person. A smart controller collects the data sent by the smart sensors and forward to the computer system through serial communication for data processing.

Captured data is dynamically changing and demanding fast real time response time for forecasting the irregular behaviour of the elder; for analyzing the data properly an efficient process of storage mechanism of sensor data onto the computer system is developed and executed. This follows that, when there are changes in status of sensor, data is recorded along with their time instance. Further, data processing is done with the help of file handling mechanism to generate the pattern of sensors usage activity. Multi level check is performed in order to determine the usages of the appliances are proper at respective time instance or not in real time. This facilitate in reduction of false alarm. At the initial check, if there is an activity of sensor during particular time duration then the sequence is flagged with regular or irregular status. This is inferred from the rules of the knowledge base. If an irregular flagged sequence is generated then the pattern of the sensors activity is then compared with the classified model of the regular or irregular pattern of the sensors.

Fig. 1 shows the newly developed zigbee based wireless sensor home monitoring network which can be used to track the uses of appliances used by the person for day-to-day activities. Fig. 2 shows the necessary electronics inside a sensing unit. The current system consists of 6 electrical appliances monitoring unit used to monitor and four force-sensors based monitoring unit. The electrical appliances such as hot water kettle, microwave oven, toaster, television, room heater and washing machine are monitored. The force sensor based units are used to monitor bed, toilet, sofa, and chair which are used by the elderly person. Other than those sensors, a panic button for emergency help and a temperature cum humidity sensor has been used in the system. The system has been continuously used for five consecutive days to collect data.



Fig1: The fabricated home monitoring system based on wireless sensors network

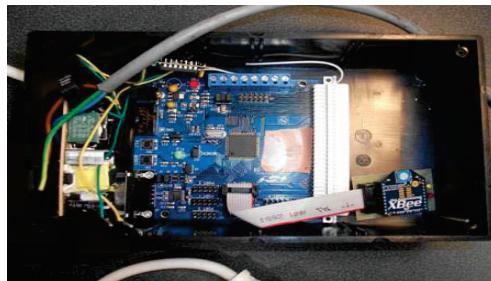


Fig 2: The electronic details of a sensing unit

3. Results

Figs. 3 and 4 illustrate the developed online data acquisition module receiving the sensor active or inactive status along with their duration. Fig. 5 shows the uses of an electrical appliance, namely the hot-water kettle in the morning duration for 3 consecutive days. The first day was Sunday, the 2nd day was Monday but was a national holiday and the 3rd day was Tuesday. It is seen that the usage is slightly different from each other. So knowledge of the usage of the appliances is very important for determining the irregular behavior of the person and consequently the abnormal situation leading to the sending of the alarm message to the caregiver.

3.1 Behavioral Pattern Analysis:

Sampled sensor activity behaviour for a particular sensor is given in Table 1. The daily pattern and likelihood is constructed from these data by applying sequential pattern matching process. Considering the following record set for various days of three hour (morning 9-11) duration sensor activity:

Day 1 : (9-11: B) 015,016,013,014,017,010 (9-11: E)
 Day 2 : (9-11: B) 016,013,014,014,010 (9-11: E)
 Day 6 : (9-11: B) 014,014,013,014,015,018,010,019,014 (9-11: E)
 Day 0 : (9-11: B) 018,018,010,019,014,014,013,014,015 (9-11: E)

On Apply of Sequential Pattern matching on sensor activity on the above set, results into the following likelihood of sensor sequence in order to know the sensor sequence pattern:

3-4,3-14-4,3-14-14-2,3-14-15-2,3-14-10-3,3-15-2,3-10-3,4-4,4-13-2,4-13-14-2,4-13-14-15-2,4-13-15-2,4-14-3,4-14-13-2,4-14-13-14-15-2,4-14-13-15-2,4-14-14-15-2,4-14-15-2,4-14-10-2,4-15-2,4-10-3,5-3,5-14-2,5-10-2,6-2,6-13-2,6-13-14-10-2,6-13-10-2,6-14-2,6-14-10-2,6-10-2,8-2,8-14-2,8-19-2,8-19-14-2,8-10-2,8-10-14-2,8-10-19-2,8-10-19-14-2,9-2,9-14-2,10-4,10-14-2,10-19-2,10-12-2.==>(3,4),(3,4,4),(3,4,5),(3,4,10),(3,5),(3,10,4),.....

Table 1: Experimental Room Heater sensor activity sequence

Day	Sensor Activity Pattern*
Week End	(0-23:B)011,0,4,1,6,S1InADur,0,16,11,011,0,26,14,6,S1InADur,0,16,2,.... 011,0,48,32,6,S1InADur,0,16,5 . 011,23,41,39,6,S1InADur,0,16,8,(0-23:E) (0-23:B)011,0,4,19,0,S1InADur,0,16,14,011,0,26,58,0,S1InADur,0,16,20,..... 011,23,18,4,0,S1InADur,0,15,38, 011,23,39,50,0,S1InADur,0,15,29,(0-23:E)
Week Day	(0-23:B)011,0,1,54,1,S1InADur,0,15,38,011,0,23,55,1,S1InADur,0,15,41,... 011,23,56,39,1,S1InADur,0,12,54,(0-23:E) (0-23:B)011,0,16,13,2,S1InADur,0,12,50,011,0,36,3,2,S1InADur,0,12,50,..... 011,0,55,37,2,S1InADur,0,12,42, ... 011,14,6,55,2,S1InADur,0,14,50,(0-23:E)

0-23B, 0-23E: Delimiters, *: sensor-id, start: hour, min, secs, day, inactive duration: hour, min, secs

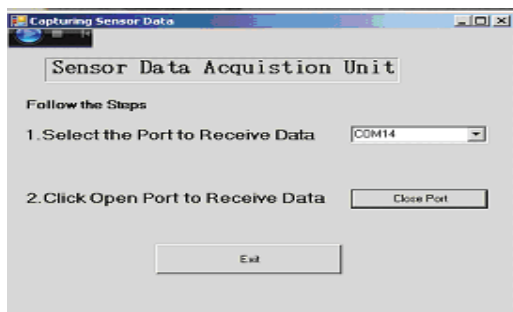
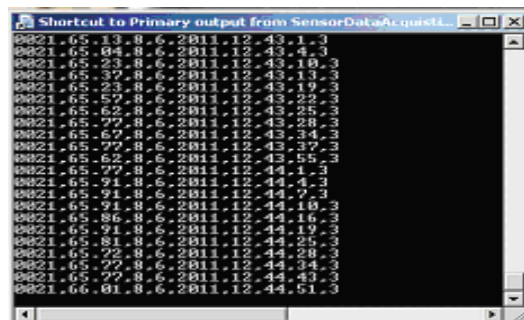


Fig. 3 Real-time data acquisition module



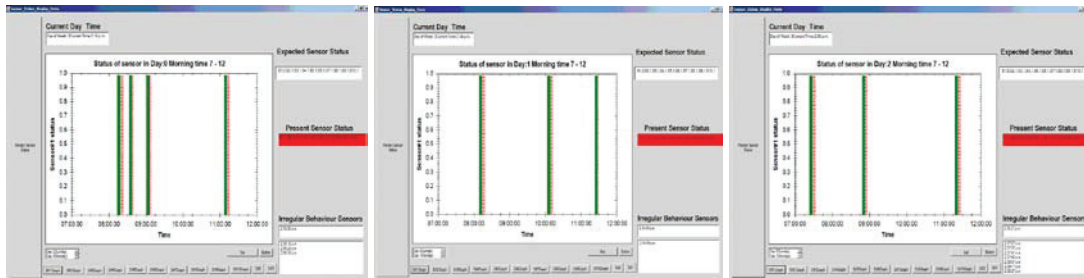


Fig. 5 The usage pattern of an electrical appliance during morning time for three consecutive days

4. Conclusion and Future Work:

In this paper a Zigbee protocol based home monitoring system has been reported. The system collects data on the usage of house hold appliances. The developed system continuously monitor the activity of elderly person staying alone based on the usage of the house hold appliances. Simultaneously, it also generates the sensor activity pattern to analyze and foresee the changes in daily activities of the elder person. In near future, the generated activity pattern related to weekdays and weekends will be used to predict the abnormal behaviour of the elderly person based on the classification model of regular and irregular sensor activity. The investigation on the real time sensor status monitoring with the double check mechanism indicates the reduction of false alarms and optimally predicting the irregular behaviour of the elder care. As the wireless sensor network is scalable, it may be possible to include other sensors if necessary in order to study highly structured behavioural pattern for more precise abnormal detection.

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